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OPTIMIZATION OF PROCESS PARAME`TER OF ELECTROCHEMICAL MACHINING OF ALUMINIUM ALLOY 7075 BY USING GRAY TAGUCHI METHOD

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Abstract - *Electrochemical machining is one of the mostly used non-conventional machining processes to machine complicated shapes for electrically conducting but difficult to machine material. ECM has wide application in aerospace, automobile, defense. Aluminium alloy 7075 is used in aerospace due to its good property and low density. Aim of the experimentation is to be finding the optimum parameter for maximum MRR and good surface finish. Experimentation is performed based on Taguchi L9 orthogonal array with three process parameter like voltage, feed rate and electrolyte concentrating with three levels. The optimum parameter obtain is voltage 15V, feed rate 0.9 mm/min, electrolyte concentration 20%. The confirmation test has been carried out to verify the improvement of performance characteristic of electrochemical machining of aluminium alloy 7075.*

Key Words: MRR, SR, Taguchi, ECM, Grey relational analysis.

1. INTRODUCTION

Electrochemical machining is the control removal of metal by anodic dissolution in an electrolytic cell in which work-piece is anode and tool is cathode. The work-piece is eroded in accordance with faraday law of electrolysis. Aerospace, automobile and defence is the sectors where ECM has most of the use.

Milan Kumar Das et.al investigate the ECM of EM31 tool by using grey relational analysis and obtained optimum parameter for good surface finish and maximum material removal rate. The controllable variable used is feed rate voltage electrolyte concentration [1,2,3]. Jia Lia et.al experimental investigates electrochemical machining of ɣ-TiAl intermetallic. Orthogonal experiment where conducted to study the effect of process parameter such as applied voltage, electrode feed rate, electrolyte pressure and temperature on material removal rate, surface roughness, machine gap in sodium chloride aqueous solution. The result indicated that electrode freed rate is the crucial effects on MRR surface roughness and machining gap are the best parameter combination determined [4,5,6,7]. Sadineni Ramarao et.al did the experimental study for radial overcut in electrochemical drilling of Al-5% B4C composite. Experiment has been conducted on electrochemical machine according to principal of Taguchi method [8,9,10,11]. The radial overcut model produce during this research work may be used in enhancing the hole quality as machining parameter optimized. R. Goswami et.al did the experiment of optimization of electrochemical machining process parameter of aluminium and mild steel using Taguchi approach. Most significant factor in case of MRR of aluminum is voltage; in case of surface roughness of aluminum is tool feed. In case of mild steel the most significant factor for MRR is voltage and in case of surface roughness it is current [12,13,].

Many authors have so far concentrated on the process improvement in ECM. In this paper the attempt has been made to obtain optimum parameters like voltage, feed rate and electrolyte concentration for aluminium alloy 7075 considering multiple properties like MRR and surface roughness by using the Grey Taguchi method.

2. Experimental procedure

2.1 Experimental setup:

Experiments are conducted on the METATECH (ECMAC) electrochemical machining equipment which is shown n figure. The ECM setup consists of machining chamber, control panel, and electrolyte circulation system. The job to be machined is fixed in the vice, in the machining chamber, that is sealed for any leakage of electrolyte and is corrosion resistant, having window to see machining operation. Tool is brought near the job with the help of press buttons provided on the control panel and table lifting arrangement, maintaining particular gap. The tool progress is maneuvered vertically by servo motor and is governed by micro controller based programmable drive. Then the process parameters are set like tool feed rate, voltage, timer, auto/manual mode, etc. the process is started in the presence of electrolyte flow i.e. circulated with the help of special pump filling the gap between anode and cathode. Electrolyte flow is adjusted by flow control valve.

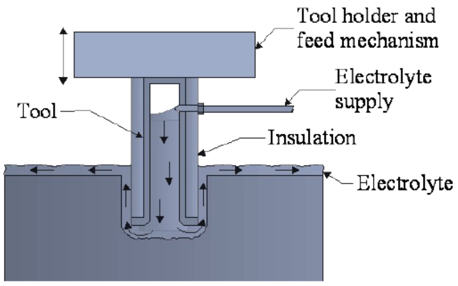

Fig. 1: Experimental setup

2.2 Work piece material, tool material and electrolyte:

Rectangular block of 50×40×11 made of Aluminium alloy 7075 (5.6-6%Zn, 2.1-2.55, 1.2-1.6% Cu and remaining Al) having high corrosion resistance and good strength is selected for the electrochemical machining. Thermal conductivity of 7075 Al alloy is 130-180 W/mK and density 2.81 gm/cm3. The copper ros is used as tool material and KCl is used as electrolyte.

2.3 Selection of machining parameters and their level:

In this study, the experimental plan has three controllable variables namely voltage, feed rate, electrolyte concentration. L9 orthogonal array of Taguchi method is used which has nine numbers of experiments for three level tests.

Table 1 Process parameters and their levels.

	Process parameter	Level 1	Level 2	Level 3
A	Voltage	15	18	21
B	Tool Feed	0.3	0.6	0.9
C	Electrolyte concentration	10	15	20

Table 2 Experimental observation

Sr No.	Voltage	Feed rate	Electrolyte conc(%)	MRR gm/min	Roughness (Ra)
1	15	0.3	10	0.1	1.838
2	15	0.6	15	0.188	4.8
3	15	0.9	20	0.286	3.023
4	18	0.3	15	0.101	2.564
5	18	0.6	20	0.134	3.986
6	18	0.9	10	0.169	5.7
7	21	0.3	20	0.16	1.93
8	21	0.6	10	0.146	4.614
9	21	0.9	15	0.298	4.3

3. Grey relational analysis:

Grey relational analysis is efficient tool for multi response analysis. It provides the necessary information of the interaction among parameters. The experimental results are normalized in the range between zero and one. Depending on the characteristics of data sequence, there are various methodologies of data preprocessing available for the GRA. The procedure is given below.

$$X^*i\ (K) = \frac{Xi(K) - \min Xi(K)}{\max Xi(K) - \min Xi(K)}$$

MRR is the important parameter in ECM which decides machinability of the material under consideration for the "larger the better" characteristic like MRR the original sequence can be normalized using above equation.

To obtain the maximum surface roughness "smaller the better" quality characteristic has been used for minimizing. The original sequence should be normalized as follows:

$$X^*i\ (K) = \frac{maxXi(K) - X_i(k)}{\max Xi(K) - \min Xi(K)}$$

Where $X^*i\ (K)$ and $X_i(k)$ are the sequence after the data preprocessing and comparability sequence respectively, k=1 for MRR and 2,3 for SR and KW and i=1,2,3....9 for experiment number 1 to 9.

Table 3 Normalized data

Sr. no	NMRR	NRa	1-NMRR	1-NRa
1	0	1	1	0
2	0.4441	0.233	0.559	0.767
3	0.9366	0.613	0.0634	0.307
4	0.0085	0.812	0.9915	0.188
5	0.1735	0.4438	0.8265	0.5562
6	0.3516	0	0.6484	1
7	0.3018	0.930	0.6982	0.07
8	0.2354	0.281	0.7646	0.719
9	1	0.3625	0	0.6375

4. Gray relational coefficient and gray relational rate:

Following data preprocessing, the gray relational coefficient is calculate to express the relationship between ideal and actual normalized experimental result. The grey relational coefficient can be express as follows:

$$\xi i(k) = \frac{\Delta \min + \Psi \Delta max}{\Delta 0i(k) + \Psi \Delta max}$$

Where $\Delta 0i(k)$ the deviation sequence of reference, sequence is $X^{*}0(K)$ and the comparability sequence is $X^{*}i\ (K)$, Ψ is distinguishing coefficient, 0 ≤ Ψ ≤ 1, the purpose of which to weaken the effect of Δmax if all parameters are given equal preferences, Ψ is taken as 0.5. The gray relational coefficient for each experiment of l9 orthogonal array can be calculated using above equation.

Table 4 Gray relational grade & order

Sr No.	GMRR	GRa	grade	Order
1	0.333	1	0.6665	3
2	0.4735	0.3946	0.4340	6
3	0.8874	0.6195	0.7534	1
4	0.3352	0.7267	0.5309	5
5	0.3769	0.4733	0.4251	7
6	0.4353	0.333	0.3841	9
7	0.4172	0.8771	0.6471	4
8	0.3953	0.410	0.4026	8
9	1	0.4395	0.7197	2

Table 5.response table for GRG

Level	Voltage	Feed rate	Electrolyte concentration
1	0.6180	0.6148	0.4844
2	0.4467	0.4206	0.5615
3	0.5898	0.6191	0.6085
Delta	0.1713	0.1985	0.1241
Rank	2	1	3

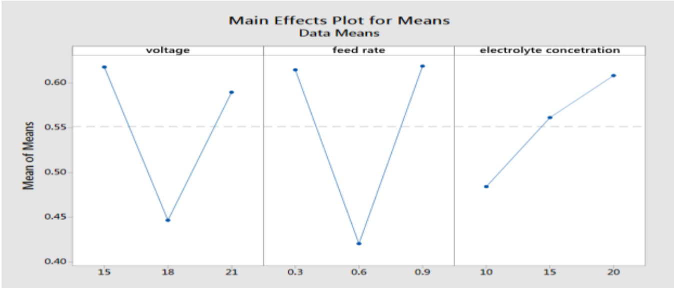

Fig-2 Main effect plot for mean of GRG

5. Confirmation test:

A confirmation test is carried out for improvement in result obtained through the condition suggested by optimum parameter analysis compared to the initial condition. Also grey relational grade calculated as follows:

$$\hat{\gamma} = \gamma_m + \sum_{i=1}^{0} (\bar{\gamma}_i - \gamma_m)$$

Where γ_m is the total mean grey relational grade, $(\gamma_i)^{-}$ is the mean grey relational grade at the optimal level, and 0 is the number of main design parameter that significantly affect MRR and Roughness. The obtained process parameters, which give higher grey relational grade, are presented in table. They predicted MRR, SR and grey relational grade for the optimal machining parameter are obtained.

Table 6. Result of confirmation test

Output response	initial data	Optimal machining parameters	
		Machining parameter in 6th trial of OA	Grey theory prediction
Level	A1B2C2	A1B3C3	A1B3C3
MRR	0.1883	0.2862	
SR	4.8	3.023	
Gray relation grade	0.434	0.7534	0.7428
Improvement in gray relation grade = 0.0106			

6. Conclusion:

An experiment was carried out to find best parameter combination and the main affecting factor on MRR and SR in ECM of aluminium alloy 7075. The optimum parameters were found out by Gray-Taguchi method. Voltage, electrolyte concentration and feed rate are considers as machining parameter, metal removal rate and surface roughness have been obtain as response from ECM process. Optimum parameter found out as follows:

Voltage: 15 V
Feed rate: 0.9 mm/min
Electrolyte concentration: 20%

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